Using "Cheat Sheets" to Distinguish Ability from Knowledge: Evidence from a Randomized Control Trial in Chile

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10 June 2014

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August 15th, 2014

Abstract

According to the existing evidence some higher education admission tests may be screening out students who, despite a relative lack of specific knowledge, possess as much intellectual ability as their peers. If this is the case, students from disadvantaged socioeconomic backgrounds are likely to be disproportionately affected, since they generally receive a primary and secondary education of worse quality than their better-off peers, often resulting in significant knowledge gaps. Also, although in some cases these formative shortcomings might be too large to be feasibly addressed at the time of enrollment in higher education, it is plausible to think that in some cases they may perhaps be relatively easy to remedy. In view of all this, in this paper I present a diagnostics experiment, aimed at helping to better understand this issue. In particular, I custom-designed a multiple-choice test, intended to measure an individual's mathematical ability, while minimizing the reliance on previously acquired knowledge. Also, I put together a two page "cheat sheet", which outlined all the necessary concepts to successfully complete the exam, without providing any explicit answers. This test was subsequently used to evaluate the candidates applying for admission into a special access program at one of the leading Chilean universities. A staged randomized control trial was used to measure the difference in academic performance (i.e. number of correctly answered questions) across the three parts of the exam between students who received a "cheat sheet" after the first or second parts of the test, respectively. As expected, "cheat sheets" improved the average performance of candidates on the exam, but their impact varied considerably across individuals. Most importantly, "cheat sheets" proved significantly more beneficial (in terms of improved test performance) to those students who were more likely to have had a secondary education of lower quality. This result has important implications for educational policies in Chile and elsewhere, suggesting that a transition to ability-focused admission tests would facilitate the access to higher education for talented students from disadvantaged backgrounds.

The views expressed in this paper are solely those of its author, and do not necessarily represent the views of, and should not be attributed to, any other individual or institution.

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First draft dated June 10th, 2014. The latest version of this paper is available at *http://www.diez-amigo.com*.

The author would like to first of all thank his thesis advisors Abhijit Banerjee, Benjamin Olken, Francisco Gallego and Michael Piore for their exceptional guidance during his graduate studies. He is also particularly grateful to Jeanne Lafortune, José Miguel Sánchez, María Verónica Santelices, José Tessada and Victoria Valdés for their advice, and to one anonymous referee and several participants in seminars at the MIT Department of Economics for their helpful comments at different stages of this research project. Moreover, this endeavour would have been fruitless without the support of the Faculty of Economic and Administrative Sciences at the Pontificia Universidad Católica de Chile, or the Abdul Latif Jameel Poverty Action Lab (J-PAL) and its office for Latin America and the Caribbean, and the author would like to thank Ryan Cooper, Amanda Dawes, Carlos Díaz, Juan Echeverría, Luz Lyon, Guillermo Marshall, Pablo Marshall, Ricardo Paredes, Ignacio Rodríguez, Francisco Rosende, Ignacio Sánchez, Claudio Sapelli, and many others at those institutions. Finally, funding for this research project was generously provided by the Caja Madrid Foundation, the Rafael del Pino Foundation, the "la Caixa" Foundation, the MIT Department of Economics, the Abdul Latif Jameel Poverty Action Lab (J-PAL) and its office for Latin America and the Caribbean, and the Pontificia Universidad Católica de Chile and its Faculty of Economic and Administrative Sciences. It is hereby very gratefully acknowledged.

JEL Classification Codes: I2, J15, O15, A12

Keywords: Equality of Opportunity, Higher Education, Education Policy, Policy Evaluation, Economic Development

1. Introduction

This paper presents a diagnostics experiment, intended to better understand the role played by admissions tests in the access to higher education (for example, on one hand admissions tests may simply be correctly measuring relevant student characteristics, arising from their education and socioeconomic environment; however, on the other hand admissions tests may be inaccurate, and/or biased towards irrelevant student characteristics). It is motivated by existing evidence which suggests that some higher education admission tests may be screening out students who, despite a relative lack of specific knowledge, possess as much intellectual ability as their peers (or even more). If this is the case, students from disadvantaged socioeconomic backgrounds are likely to be disproportionately affected, since they generally receive a primary and secondary education of worse quality than their better-off peers, often resulting in significant knowledge gaps. Also, although in some cases these formative shortcomings might be too large to be feasibly addressed at the time of enrollment in higher education, it is plausible to think that in some cases they may perhaps be relatively easy to remedy.

In view of all this, I custom-designed a multiple-choice mathematical ability test, intended to measure an individual's ability while minimizing the reliance on previously acquired specific knowledge (as discussed for example in Bransford, 1999, or Pellegrino, 2001, this in itself is obviously far from a trivial task, but I trust that the result is satisfactory). Moreover, I also put together a two page knowledge summary, or "cheat sheet", which outlined all the concepts which I considered necessary to successfully complete the test (copies of both the "cheat sheet" and the full mathematical ability test are included in the Appendix). Obviously, this was intended to improve test performance, but it is worth noting that the "cheat sheets" did not provide any explicit answers. This was purposely so, in order to ensure that "cheat sheets" did not just raise the grades for all students, but rather, that they only helped those who were able to successfully apply the general concepts outlined in them to the resolution of the specific exam questions. Given this, and the fact that knowledge summaries should only improve the performance of students who did not previously know the concepts outlined in them, "cheat sheets" were expected to still allow for meaningful variation in grades, while at the same time potentially improving screening. In particular, it was anticipated that talented students from disadvantaged socioeconomic backgrounds who possessed good mathematical reasoning capabilities might be able to overcome their potential knowledge gaps with the help of the "cheat sheets". However, this was far from a trivial conclusion, as the formative shortcomings attributable to a primary and/or secondary education of a lower quality might be too large to allow students from disadvantaged socioeconomic backgrounds to benefit from the knowledge summaries.

This mathematical ability test was subsequently used to screen candidates applying for admission into the Commercial Engineering degree at the Pontificia Universidad Católica de Chile via the "Talento + Inclusión"

(*Talent + Integration*) special access program, which targets students from disadvantaged socioeconomic backgrounds (see Díez-Amigo, 2014, for a full description of this access program). The mathematical ability test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous)[1], and candidates were randomly divided into treatment and control groups. All students took the first part of the test without any support materials, but then the "cheat sheet" was distributed to each of the candidates in the treatment group, who had about ten minutes to examine it before the second part of the exam started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed its second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, when they had to return it. This staged randomization design allowed to estimate the impact of the "cheat sheet" on student test performance, by looking at the differences in the number of questions answered correctly across the three parts of the test between students in the control and treatment groups.

After performing the above described experiment, this paper only finds a significant difference in the number of questions answered correctly between students in the treatment and control group in Part II of the test. Since this was precisely the part in which candidates in the control group did not yet have access to the "cheat sheet" (as opposed to students in the treatment group), this suggests that as expected having access to a knowledge summaries improved test performance, *ceteris paribus* resulting in about one additional question answered correctly (out of a total of fifteen). Also, this paper also finds a significant difference in the improvement (i.e. additional number of questions answered correctly) from Part I to Part II and from part II to Part III between students in the treatment and control groups. In particular, students in the treatment group on average answered correctly almost one additional question in Part II than in Part I, compared to students in the control group who did not have access to a "cheat sheet" during the second part of the test. Analogously, students in the control group on average answered correctly more than half an additional question in Part III than in Part II, after receiving a knowledge summary before the third part of the exam, which again suggests that having access to a knowledge summaries increases student performance on the test. Moreover, students who attended a secondary school with a higher average score in the government-administered standardized evaluation test (SIMCE) tended to answer more questions correctly, consistent with stylized fact of positive correlation between secondary school quality and admission test scores.

All the previous makes sense, and corroborates the fact that, as anticipated, students perform better in a test if they have access to a "cheat sheet", and/or if they attended a secondary school of better quality. However, while observing the opposite phenomenon would have raised some concerns, this result is not particularly

[1]For comparison purposes, the questions in each part of the test would ideally be the same. However, this would obviously raise some concerns even if the students do not know the answers to the test. Therefore, different but analogous questions were used. This means that the underlying concept of the question was the same, but the precise numbers or examples used differed from one part to another.

interesting. Nonetheless, most importantly this paper also finds robust evidence that "cheat sheets" were significantly more beneficial for those students who were more likely to have had a secondary education of lower quality. In particular, students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) tended to experience a significantly greater differential improvement in the number of questions answered correctly when using a "cheat sheet". Or in other words, there is evidence of a significant negative effect of secondary school government-administered standardized evaluation (SIMCE) on the differential improvement in test performance after students have access to a "cheat sheet". This is observable both in the significantly greater differential improvement from Part I to Part II for students in the treatment group (i.e. after they received the "cheat sheet" at the end of the first part), and in the significantly greater differential improvement from Part II to Part III for students in the control group (i.e. after they received the "cheat sheet" at the end of the second part). Also, no differential impact is observed for the comparisons of Part III vs. Part I, consistent with the fact that all candidates completed both Part I and Part III in the same conditions (no differential impact should be expected in this case, unless having access to the "cheat sheet" for a longer amount of time does matter).

Moreover, although the results are less robust than those presented above, this paper also finds some evidence of a positive differential impact of having access to a "cheat sheet" on candidates enrolled in the PENTA UC program for talented secondary school students. Since students enrolled in the PENTA UC program come from disadvantaged backgrounds, and were already screened during their secondary education and identified as possessing "exceptional ability", this suggests that *ceteris paribus* the use of "cheat sheets" may be particularly beneficial for talented students. Also, there is some evidence that while students from public schools or the lower quintiles of the income distribution may benefit from "cheat sheets", they may need more time to do so than the amount provided between the parts of the exam in this experiment (e.g. because they may need more time to analyze and comprehend it).[2]

Finally, a simulation exercise is performed for illustration purposes. It consists of an analysis of which candidates would benefit from (or would be worse off with) the use of cheat sheets, as measured by whether they advanced to or were relegated from the group of top 20 candidates (which is the number of vacancies available each year for admission via the special access program featured in this study). This is performed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. The results of this exercise are not robust at the candidate level, since given the reduced number of questions in each part of the test, and the left-skewed distribution of

[2]Note that while these results would again point in the same direction of the results discussed above, these relationships are confounded by the fact that the control group also received "cheat sheets" at the end of the second part. Therefore, it is not possible to identify whether these are in fact delayed improvements in the treatment group, or if (although unlikely) the "cheat sheet" instead had a negative impact on the test performance of some students in the control group after they had access to it.

the number of correctly answered questions, there are many ties which are broken randomly. However, they provide an insight of how the introduction of "cheat sheet" may have affected the selection process, if the mathematical ability test was the only criterion used to determine admission. In particular, according to the results of this simulation exercise the use of "cheat sheets" would mainly affect students close to the cut-off, but there are also cases of very large changes in ranking from Part I to Part III of the test. For example, one student only answered correctly to 10 questions (66 %) in Part I, and at that point would not have ranked in the top 100 among all candidates who took the test. However, after receiving the "cheat sheet" s/he answered correctly all 15 questions (100 %) in Part III, and made it to the top 10.[3]

The rest of this paper is organized as follows: Section 2 presents the motivation and background for the paper; Section 3 provides a description of the mathematical ability test custom-designed for the analysis[4]; Section 4 provides a description of the randomized control trial design; Section 5 outlines the main findings; Section 6 discusses the robustness of the analysis; Section 7 concludes.

2. Motivation

Chile, albeit a middle-income country and an OECD member, faces substantial gaps in the provision of higher education. For example, while the OECD average net coverage of higher education (i.e. the ratio of students 18-24 years old enrolled in higher education) is 59 %, the net coverage of higher education in Chile in is 36.3 %, and the net coverage for the poorest decile of the population is 16.4 % (OECD, 2011). Moreover, poor students usually attend public or subsidized public schools, while better-off students usually attend private schools, which generally feature higher quality. Only 10 % of public secondary school graduates attend elite universities, versus 31 % for private schools, resulting in a clear majority of private school students in high quality undergraduate institutions. Also, lengthy degrees (lasting 13.6 semesters on average) make education comparatively costly, and there is great variance (3:1 to 5:1) in income among graduates, even within the same degree (Comisión de Financiamiento Estudiantil para la Educación Superior, 2012). The Pontificia Universidad Católica de Chile, the university in which this study was carried out, and one of the top in the country, is a good example of the above: 71.7 % of students come from households in the upper quintile of the income distribution, versus 3.4 % from its lower quintile. The pattern is even more pronounced in the most prestigious degrees: for example, ordinary admission into its Commercial Engineering degree usually requires a score of 730 or more in the "Prueba de Selección Universitaria", or PSU (the standardized admission test administered at the national level). That score corresponds to the 98 % percentile of the distribution, and

[3]It is worth noting that although s/he was in the treatment group, s/he only answered one additional question correctly in Part I with respect to Part II, with the sharp improvement instead occurring from Part II to Part III. This again suggests that students may benefit from having more time to review the "cheat sheet".

[4]The "cheat sheet" and the full mathematical ability test are included in the Appendix.

not surprisingly, the overwhelming majority of the 250 new students admitted each year attended private secondary schools, and belong to households in the two upper quintiles of the income distribution (DEMRE, 2011, and Dirección de Servicios Financieros Estudiantiles, 2011

Then, it is not surprising that the access to higher education is one of the most pressing issues for Chilean society. Therefore, there is an ongoing debate, both at the government and university levels, regarding which is the best way to increase the access to higher education, and to ensure equality of opportunity for. Of course, the first best solution would be to increase the quality of secondary education in public and subsidized secondary schools, and there currently are may efforts in this direction. However, although necessary, any such reforms will at best improve the access to higher education only in the long term. In view of this, there are also many initiatives aimed at improving the access to higher education in the short and medium term. For example, an important barrier to access is the cost of higher education, which makes it prohibitive for many households. The government has been expanding public funding, but this is many times only partial (it doesn't cover the full tuition fees), and stipends to cover living expenses are very rare (e.g. see Sánchez, 2011, for a pre-2014 reform discussion of the challenges facing the higher education system in Chile; or Williamson and Sánchez, 2009, who discuss the necessary basic features of a potential government-funded public higher education system in Chile). Moreover, in order to address potential incentive problems this funding many times takes the shape of loans. However, this may have information and risk aversion implications which are not clear, particularly in a middle- or low- income development country setting with high uncertainty regarding the returns to education (e.g. see Dinkelman and Martinez, 2011, who using an experimental design evaluate the role of information about financial aid in the access to higher education in Chile; or Hoxby and Turner, 2012, who also look at the issue in the United States using a randomized control trial). However, at the forefront of the debate is the role of the PSU (the current standardized admission test), because of a perceived bias against students from public and subsidized secondary schools, and also because most poor students cannot afford the test preparation courses ("preuniversitarios") which are widespread among their better-off counterparts (for a related study on the subject in Chile see Banerjee et al, 2012). There have been several attempts and proposals to reform the PSU (e.g. see Santelices et al, 2011), and the Chilean Ministry of Education has recently included the school class ranking (i.e. the ranking of students with respect with their secondary school peers) in the weighting formula to determining the final score to be considered for admission purposes. However, this remains an open issue, and it is also worth noting that although the access to higher education is at the forefront of the public debate in Chile at the moment, this is of course an issue which is considered key in almost any other country (including the United States, e.g. see Dickert-Conlin and Rubenstein, 2007). The findings of this paper are therefore relevant for, and contribute to, the overall academic debate on how to improve the access to higher education.

With the above in mind, this paper proposes a diagnostics experiment, intended to better understand the role of admissions tests in the access to higher education (for example, on one hand admissions tests may simply be correctly measuring relevant student characteristics, arising from their education and socioeconomic environment; however, on the other hand admissions tests may be inaccurate, and/or biased towards irrelevant student characteristics). It is motivated by existing evidence which suggests that some higher education admission tests may be screening out students who, despite a relative lack of specific knowledge, possess as much intellectual ability as their peers, or even more (it is worth noting that as mentioned for example in Heckman, 1995, in any case latent ability alone cannot explain differences in test scores or wages among individuals, nor is independent of an individual's context). If this is the case, students from disadvantaged socioeconomic backgrounds are likely to be disproportionately affected, since they generally receive a primary and secondary education of worse quality than their better-off peers, often resulting in significant knowledge gaps. Also, although in some cases these formative shortcomings might be too large to be feasibly addressed at the time of enrollment in higher education, it is plausible to think that in some cases they may perhaps be relatively easy to remedy.

All the above is fully compatible with Bloom's seminal "Taxonomy of Educational Objectives", which classifies *Knowledge* as the first but lowest of educational goals, followed by *Comprehension* and *Application* (see Bloom et al, 1956, for a discussion of the original taxonomy; and Krathwohl, 2002, for a proposed modern revision to it). This is, secondary students who do not *know* the answers to the questions proposed to them in a test may not necessarily be less talented, or less likely to succeed in higher education. On the contrary, if with the help of a "cheat sheet" they can overcome their knowledge gaps, by quickly *comprehending* and *applying* the concepts outlined in it, this probably means that they are actually as likely to succeed in higher education (at least when provided with the adequate means to overcome their secondary education shortcomings). Or in other words, "cheat sheets" may help to better distinguish knowledge from ability (as reflected on better comprehension and application of concepts) in admission tests, leveling the playing field for students from disadvantaged socioeconomic backgrounds.

Also, it is worth noting that similar practices to the "cheat sheets" are common in many education contexts. For example, some exams at the university level can be taken "with the book open" (i.e. with any support materials that the student may deem useful), or are "take home" (i.e. the student completes the test on her or his own, without supervision)[5]. Also, it seems that consistent support materials are generally allowed and/or encouraged in those contexts in which pure knowledge is considered as secondary, or even irrelevant (e.g. mathematics or statistics).

[5]While "take home" exams will not necessarily allow the of use support materials, many do so.

3. Mathematical Ability Test

In view of all the above, I custom-designed a multiple-choice mathematical ability test, intended to measure an individual's ability, while minimizing the reliance on previously acquired specific knowledge (as discussed for example in Bransford, 1999, or Pellegrino, 2001, this in itself is obviously far from a trivial task, but I trust that the result is satisfactory). The type of questions used in the test were inspired by those featured in the previous national standardized admissions test in use in Chile until 2002, the "Prueba de Aptitud Académica", or *Academic Aptitude Test* (e.g. see Tapia Rojas et al, 1996). Moreover, I also created a two page knowledge summary, or "cheat sheet", which outlined all the concepts which I considered necessary to successfully complete the test (copies of both the "cheat sheet" and the full mathematical ability test are included in the Appendix).

Obviously, this was intended to improve test performance, but it is worth noting that the "cheat sheets" did not provide any explicit answers. This was purposely so, in order to ensure that "cheat sheets" did not just raise the grades for all students, but rather, that they only helped those who were able to successfully apply the general concepts outlined in them to the resolution of the specific exam questions. Given this, and the fact that knowledge summaries should only improve the performance of students who did not previously know the concepts outlined in them, "cheat sheets" were expected to still allow for meaningful variation in grades, while at the same time potentially improving screening. In particular, it was anticipated that talented students from disadvantaged socioeconomic backgrounds who possessed good mathematical reasoning capabilities might be able to overcome their potential knowledge gaps with the help of the "cheat sheets". However, this was far from a trivial conclusion, as the formative shortcomings attributable to a primary and/or secondary education of a lower quality might be too large to allow students from disadvantaged socioeconomic backgrounds to benefit from the knowledge summaries.

The mathematical ability test was subsequently used to screen candidates applying for admission into the Commercial Engineering degree at the Pontificia Universidad Católica de Chile via the "Talento + Inclusión" (*Talent + Integration*) special access program, which targets students from disadvantaged socioeconomic backgrounds (see Díez-Amigo, 2014, for a full description of this access program).The mathematical ability test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous). For comparison purposes, the questions in each part of the test would ideally be the same. However, this would obviously raise some concerns even if the students do not know the answers to the test. Therefore, different but analogous questions are used (this means that the underlying concept of the question is the same, but the precise numbers or examples used differ from part to part). Candidates were randomly divided into treatment and control groups: all students took the first part of the test without any support materials, but then the "cheat sheet" was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test (when they had to return it). For fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with other criteria. Also, although the tests were strictly monitored to avoid cheating or copying among students, as a further precaution two versions of the tests were distributed, featuring the same questions in a different order.

4. Randomized Control Trial

The staged randomization design described above allows to estimate the impact of "cheat sheets" on test performance, by looking at the differences in the number of questions answered correctly across the three parts of the test between students in the control and treatment groups. In particular, it is possible to compare the difference in the number of questions answered correctly between Part I - Part II and Part II - Part III in the treatment and control groups.[6] Also, it is possible to compare how all students performed in the first part compared to the third part of the exam, and see which students would benefit from or be worse off with the use of "cheat sheets". Finally, it is possible to analyze what is the relationship between the observable student characteristics and the improvement in performance when having access to a "cheat sheet", or with the likelihood of benefiting from or be worse off with its use.

A total of 175 candidates took the mathematical ability test, over the 2013 and 2014 academic year application periods. 57 students took it at the end of 2012 and 118 took it at the end of 2013, respectively. They were randomly divided into treatment and control groups, which had access to a "cheat sheet" after the first or second parts of the exam, respectively. For the 2013 application period students were assigned to treatment and control using a stratified randomization. The strata used were: (i) the average score obtained by the secondary school of origin in the standardized SIMCE test, administered to all secondary school students by the Chilean government (note that this is an aggregate measure of secondary school quality, not to be confused with the individual score obtained in admission tests); (ii) whether the student attended a secondary school in the Santiago Metropolitan Region; (iii) whether the student attended a public or subsidized secondary school (note that only students from public or subsidized schools are considered); (iv) whether the student attended the PENTA UC program for talented secondary school students; (v) the quintile of the income

[6] Note, however, that the difference in performance between Part I and Part II need not be comparable with the difference in performance between Part II and Part III. For example, if there is non-linear "learning by doing", or simply if students become tired towards the end of the exam

distribution to which the student belongs (note that fifth quintile students were not eligible to apply for special admission); and (vi) the student's gender (1 = male). Stratification guarantees balance across strata in the treatment and controls groups, and is particularly important in this case (given the reduced population size, which may have caused balance problems if simple random assignment had been used). Due to logistical limitations, for the 2014 application period simple random assignment was used to divide the students into treatment and control groups (i.e. no strata were taken into account). In total, 79 students were assigned to the treatment group, while 96 were assigned to control. The balance across the two groups is presented on Table I, but as expected the joint orthogonality hypothesis cannot be rejected for any of the observed student characteristics.[7]

Table II presents the frequency histograms for the number of correct answers in each of the three parts of the mathematical ability test, by treatment and control group. As it can be observed, it seems that the distribution may be skewed to the left and/or truncated at the maximum possible number of correct answers (particularly after the "cheat sheets" were distributed).

5. Findings

5.1. Do the "Cheat Sheets" Impact the Performance of Students?

Table III analyzes the differences in the number of correct answers in each of the three parts of the mathematical ability test between treatment and control groups. The dependent variable in all regressions (columns) is the number of correct answers in each corresponding part of the test, and independent variables are listed on the left (rows). Apart from the treatment indicator (first row), for robustness purposes several additional controls are included in the extended specifications (1.2, 2.2 and 3.2). In particular, the linear regression models presented in Table III are represented as

$$(.1) \quad \mathrm{y}_{ik} = \beta_0 + \delta_1 T_i + year + e_i$$

$$(.2) \quad \mathrm{y}_{ik} = \beta_0 + \delta_1 T_i + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i$$

[7] Note that three students who took the mathematical ability test but were found to be ineligible to participate in the special access program due to having attended a private school and/or belonging to the top quintile of the income distribution are excluded from the analysis. Also, it is worth noting that although all students took the test in their assigned group, there were a few students who signed up to take the test but did not show up on the day of the exam and were excluded from the special access program and this analysis. However, the number of no-shows was very limited and affected similarly both the treatment and control groups.

where y_{ik} is the number of questions answered correctly by student i in part $k = 1, 2, 3$ of the test, T_i is an indicator variable denoting whether the student was assigned to the control or treatment group, *year* is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect), and $x_{hi}h = \{1, ..., 6\}$ are the additional student characteristics which are included in the extended specifications (1.2, 2.2 and 3.2) for robustness purposes. These are the same variables used as strata in the random assignment for the 2013 cohort, i.e.: (i) average score obtained by the secondary school of origin in the standardized test administered to all secondary school students by the Chilean government (SIMCE); (ii) whether the student attended a secondary school in the Santiago Metropolitan Region; (iii) whether the student attended a public school, as opposed to a subsidized one (again, private school students were not eligible to apply for special admission); (iv) whether the student attended the PENTA UC program for talented secondary school students; (v) whether the student belongs to the lower three quintiles of the income distribution (as opposed to the fourth quintile, since as mentioned fifth quintile students were not eligible to apply for special admission); and (vi) the student's gender (1 = male). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

Analogously to the above, Table IV analyzes the differences in the improvement (i.e. additional number of correct answers) across each of the three parts of the mathematical ability test between treatment and control groups. The dependent variable in all regressions (columns) is the number additional correct answers across the corresponding parts of the test, and independent variables are listed on the left (rows)[8]. As before, apart from the treatment indicator (x.0), several additional controls are included in the (x.1) specifications for robustness purposes. The (x.2) specifications further include the interaction terms between the treatment indicator and the additional controls. In particular, the linear regression models presented in Table IV are represented as

$$(.0) \quad \mathrm{y}_{ikl} = \beta_0 + \delta_1 T_i + year + e_i$$

$$(.1) \quad \mathrm{y}_{ikl} = \beta_0 + \delta_1 T_i + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i$$

$$(.2) \quad \mathrm{y}_{ikl} = \beta_0 + \delta_1 T_i + \sum_{h=1}^{6} \beta_h x_{hi} + \sum_{h=1}^{6} \gamma_h T_i x_{hi} + year + e_i$$

where y_{ikl} is the number of additional questions answered correctly by student i in part $k = 1, 2$ compared to part $l = 2, 3$ of the test, T_i is an indicator variable denoting whether the student was assigned to the control or treatment group, *year* is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect), and $x_{hi}h = \{1, ..., 6\}$ are student characteristics which as mentioned are included

[8] For example, in columns (1.0, 1.1 and 1.2 the dependent variable is the number of additional correct answers for each students in Part II of the mathematical ability test, compared to Part I.

in the extended specifications (1.2, 2.2 and 3.2) for robustness purposes. Once again these are the same variables used as strata in the random assignment of the 2013 cohort, i.e.: (i) average score obtained by the secondary school of origin in the standardized test administered to all secondary school students by the Chilean government (SIMCE); (ii) whether the student attended a secondary school in the Santiago Metropolitan Region; (iii) whether the student attended a public school (as opposed to a subsidized one); (iv) whether the student attended the PENTA UC program for talented secondary school students; (v) whether the student belongs to the lower three quintiles of the income distribution (as opposed to the fourth one); and (vi) the student's gender (1 = male). As before Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

As it can be observed on Table III, this paper only finds a significant difference in the number of questions answered correctly between students in the treatment and control group in Part II of the test. Since as described above this is precisely the part in which candidates in the control group did not yet have access to the "cheat sheet" (as opposed to students in the treatment group), this suggests that *ceteris paribus* having access to a knowledge summaries results in about one additional question answered correctly (out of a total of fifteen). Also, as expected it seems that students who attended a secondary school with a higher average score in the government-administered standardized evaluation test (SIMCE) tend to answer more questions correctly. This is consistent consistent with the stylized fact of positive correlation between secondary school quality and admission test performance. All these results are robust to the inclusion of the additional controls.

Moreover, as it can be observed on Table IV, this paper also finds a significant difference in the improvement (i.e. additional number of questions answered correctly) from Part I to Part II and from part II to Part III between students in the treatment and control groups. In particular, students in the treatment group on average answer correctly almost one additional question in Part II than in Part I, compared to students in the control group who did not have access to a "cheat sheet" during the second part of the test. Analogously, students in the control group on average answer correctly more than half an additional question in Part III than in Part II, after receiving a knowledge summary before the third part of the exam. This again suggests that, as anticipated, having access to a knowledge summaries indeed increased student performance on the test. These results are also robust to the inclusion of the additional controls.

5.2. Are Some Students Differentially Impacted by the Use of "Cheat Sheets"?

All the above makes sense, and corroborates the fact that, as expected, students perform better in a test if they have access to a "cheat sheet", and/or if they attended better secondary schools. However, while observing the opposite phenomenon would have raised some concerns, this set of results is not particularly interesting). Nonetheless, most importantly this paper also finds significant evidence that some students were differentially impacted by the “cheat sheets”. In particular, *ceteris paribus* “cheat sheets” were significantly more beneficial for those students who were more likely to have had a secondary education of lower quality. This is, students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) experienced a significantly greater differential improvement in the number of questions answered correctly when using a “cheat sheet”. Or in other words, there is evidence of a significant negative effect of secondary school government-administered standardized evaluation (SIMCE) on the differential improvement in test performance after students have access to a “cheat sheet”. This is observable both in the significantly greater differential improvement from Part I to Part II for students in the treatment group (i.e. after they received the “cheat sheet” at the end of the first part), and in the significantly greater differential improvement from Part II to Part III for students in the control group (i.e. after they received the “cheat sheet” at the end of the second part). Also, no differential impact is observed for the comparisons of Part III vs. Part I. This is consistent with the fact that all candidates completed both Part I and Part III in the same conditions, since no differential impact should be expected in this case (unless having access to the “cheat sheet” for a longer amount of time does matter).

Also, although the results are less robust than those presented above, this paper also finds some evidence of a positive differential impact of having access to a “cheat sheet” on candidates enrolled in PENTA UC (an extension program for talented secondary school students). Since students enrolled in this program come from disadvantaged backgrounds, and were already screened during their secondary education and identified as possessing “exceptional ability”, this suggests that *ceteris paribus* the use of “cheat sheets” may be particularly beneficial for talented students. Also, there is some evidence that while students from public schools or the lower quintiles of the income distribution may benefit from “cheat sheets”, they may need more time to do so (or at least more than the amount which was provided in this experiment), for example because they need some time to analyze and comprehend it. These results point in the same direction of the results discussed above, but these relationships are confounded by the fact that the control group also received “cheat sheets” at the end of the second part. Therefore, it is not possible to identify whether these are in fact delayed improvements in the treatment group, or if (although unlikely) the “cheat sheet” instead had a negative impact on the performance of some students in the control group after they received it. Finally, a few other significant relationships can be observed on Table IV, but no other robust causal relationships have been detected.

Table V further analyzes the relationship between the improvement (i.e. additional number of correct answers) across each of the parts of the mathematical ability test and the student characteristics, by looking separately at the treatment and control groups. Each column corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other: in the first set of regressions (,1) the dependent variable is the improvement between Part I and Part

II of the test for students in the treatment group, who received the cheat sheet before taking the second part of the exam; in the second set of regressions (,2) the dependent variable is the improvement between Part II and Part III of the test for students in the control group, who received the cheat sheet before taking the third part of the exam. All six independent variables are first considered jointly (0.), and then separately (1. -6.). In particular, the linear regression models presented in Table V are represented as

$$(0.1) \qquad \mathrm{y}_i = \beta_0 + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i \text{ if } T_i = 1$$

$$(1.1{-}6.1) \quad \mathrm{y}_i = \beta_0 + \beta_h x_{hi} + year + e_i \text{ if } T_i = 1$$

$$(0.2) \qquad \mathrm{y}_i = \beta_0 + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i \text{ if } T_i = 0$$

$$(1.2{-}6.2) \quad \mathrm{y}_i = \beta_0 + \beta_h x_{hi} + year + e_i \text{ if } T_i = 0$$

where y_i is the number of additional questions answered correctly by student i in Part II compared to Part I (0,1) – (6,1) or in Part III compared to Part II (0,2) – (6,2), *year* is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect), and $x_{hi}h = \{1, ..., 6\}$ are once again student characteristics. As before these are the same variables used as strata in the 2013 random assignment, i.e.: (i) average score obtained by the secondary school of origin in the standardized test administered to all secondary school students by the Chilean government (SIMCE); (ii) whether the student attended a secondary school in the Santiago Metropolitan Region; (iii) whether the student attended a public school (as opposed to a subsidized one); (iv) whether the student attended the PENTA UC program for talented secondary school students; (v) whether the student belongs to the lower three quintiles of the income distribution (as opposed to the fourth one); and (vi) the student's gender (1 = male). As usual Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

As it can be observed on Table V, this approach again finds evidence that the performance of students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) improved significantly more than that of their peers when being able to use a "cheat sheet". This supports the above presented results, and again suggests that *ceteris paribus* the use of "cheat sheets" was particularly beneficial for students with a secondary education of worse quality. Apart from the above, a few other significant relationships can again be observed on Table V, but as in the case of Table IV no other robust causal relationships have been detected.

5.3. Which Students Benefit From (or Are Worse Off With) the "Cheat Sheets"?

For illustration purposes, let's ignore the rest of the criteria used in the special admission program, and assume that the mathematical ability test would have determined admission to the university on its own. If only 20 slots were available, who would benefit from (or be worse off with) the use of "cheat sheets"?. Or in other words, who would make it to the top 20 in Part I, but be excluded from it on Part III?[9]

Table VI presents a roster of all the students who benefit from, or are worse off with, the use of cheat sheets. This is measured by whether they advanced to, or were relegated from, the group of top 20 candidates who would be admitted via the special access program. This is observed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct students are resolved randomly, so the results of this exercise are not robust at the candidate level (given the reduced number of questions in each part of the test, and the left-skewed distribution of the number of correctly answered questions, there are many ties which are broken randomly). However, they provide an overview of how the introduction of "cheat sheets" would have affected the admission process. Each row corresponds to one student, for which the rank and number of correct answers in each of the three parts of the mathematical ability test are listed. Finally, the last column indicates whether the student was in the treatment or control group.

As it can be observed on Table VI, according to the results of the exercise the use of "cheat sheets" seems to mainly affect students close to the cut-off, but there are also cases of very big changes in ranking. For example, one student only answered correctly to 10 questions (66 %) in Part I, so that at that point would not have ranked in the top 100 among all candidates who took the test. However, with the "cheat sheet" in Part III s/he answered correctly to all 15 questions (100 %), and would have subsequently made it to the top 10[10].

Table VII then analyzes the relationship between student characteristics and the likelihood of benefiting from (or being worse off with) the use of cheat sheets. This is measured as the likelihood of advancing to (or being relegated from) the group of top 20 candidates who would be admitted via the special access program. As in the case above, this is obtained by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students

[9] Note that in reality 20 special access vacancies were available for each of the 2013 and 2014 admission years, so that 40 vacancies would be available for the two cohorts.

[10] Note that although s/he was in the treatment from Part I to Part II, s/he only answered one additional question correctly, with the sharp improvement occurring from Part II to Part III. This again suggests that students may benefit from having more time to review the "cheat sheet".

with the same number of correct students are again resolved randomly, and as before this may affect which particular students make it or not to the top 20, but the results are in any case quantitatively comparable. Each column of the table corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other: in the first set of regressions (,1) the dependent variable is the binomial indicator of whether the student benefited from the use of a cheat sheet (i.e. whether s/he made it to the top 20 in Part III but not Part I); in the second set of regressions (,2) the dependent variable is the binomial indicator of whether the student was worse off with the use of a cheat sheet (i.e. whether s/he made it to the top 20 in Part I but not Part III). All six independent variables are first considered jointly (0.x), and then separately (1.x-6x). In particular, the linear regression models presented in Table VI are represented as

$$(0.1) \qquad y_{1i} = \beta_0 + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i$$

$$(1.1\text{–}6.1) \qquad y_i = \beta_0 + \beta_h x_{hi} + year + e_i$$

$$(0.2) \qquad y_{2i} = \beta_0 + \sum_{h=1}^{6} \beta_h x_{hi} + year + e_i$$

$$(1.2\text{–}6.2) \qquad y_i = \beta_0 + \beta_h x_{hi} + year + e_i$$

where y_{1i} is an indicator variable equal to one if the student benefited from the use of a cheat sheet (i.e. whether s/he made it to the top 20 in Part III but not Part I), y_{2i} is an indicator variable equal to one if the student was worse off with the use of a cheat sheet (i.e. whether s/he made it to the top 20 in Part I but not Part III), and $year$ is an indicator variable denoting whether the student belongs to the 2014 cohort (year fixed effect). As before, $x_{hi}h = \{1, ..., 6\}$ are observable student characteristics. As usual these are the same variables used as strata in the random assignment for the 2013 cohort, i.e.: (i) average score obtained by the secondary school of origin in the standardized test administered to all secondary school students by the Chilean government (SIMCE); (ii) whether the student attended a secondary school in the Santiago Metropolitan Region; (iii) whether the student attended a public school (as opposed to a subsidized one); (iv) whether the student attended the PENTA UC program for talented secondary school students; (v) whether the student belongs to the lower three quintiles of the income distribution (as opposed to the fourth one); and (vi) the student's gender (1 = male). As usual Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

Unfortunately, the estimated coefficients from this specification, presented on Table VII, are very sensitive to the above described random tie breaking among students who answered correctly to the same number of questions. This can have a great impact on the characteristics of the candidates who would be "worse-off" and “better-off” with the introduction of “cheat sheets”, and therefore these results are presented in this paper for illustration purposes but not further discussed.

6. Robustness

Given the relatively reduced number of students involved in the study, the main robustness concern is precision, i.e. limited statistical power. Although this would not affect the validity of the main results presented, which seem to be very robust, this would reduce the likelihood of observing smaller effect sizes (and therefore the lack of an observed significant effect in this study must be interpreted as lack of evidence, not as proof of non-existence). On a related note, given the limited size of the sample both the Central Limit Theorem and the Law of Large Numbers (on which the standard linear regression models rely) might not hold, potentially threatening the validity of the econometric models used. However, given that the pooled sample for academic years 2013 and 2014 features in excess of 150 observations, this is considered unlikely (and no evidence of it is found).

Also, as already mentioned some students who signed up for the test and were included in the stratified random assignment did not show up. However, the number of individuals who signed up but did not show up was very reduced, and no differential pattern is observable, either among the no-shows, or across the treatment and control groups. Therefore, this is not considered a threat to internal validity.

Moreover, although the random assignment (stratified in 2013, simple in 2014) seems to have been quite successful, and the balance across treatment and control groups seems to be quite robust, the randomized control trial design only guarantees the exogeneity of the treatment (i.e. the use of “cheat sheets” in Part II of the test). All the other student characteristics discussed in this paper are therefore potentially endogenous, and their relationship with the independent variables in the specifications above should be interpreted with care. That said, given that as mentioned before the pooled sample for academic years 2013 and 2014 features in excess of 150 observations, as that as it can be observed on Table I the joint orthogonality hypothesis cannot be rejected for any of the observed student characteristics, this is again not considered a serious threat to internal validity.

Furthermore, note that the most robust comparison of treatment and control is that of the difference in the number of correctly answered questions between Part I and Part II of the exam (i.e. columns (1.x) in Table IV). This is because, as already mentioned, the comparison of Part III and Part II is confounded by the fact that the control group also received “cheat sheets” at the end of the second part, so that it is not possible to identify whether the observed impacts are delayed improvements in the treatment group (or if for example the “cheat sheet” instead had a negative impact on the performance of some students in the control group after they received it). Also, note that according to Table IV there is some evidence that some students in the treatment group improved significantly more from Part I to Part III, compared to their counterparts in the control group. This may indicate that receiving the “cheat sheet” earlier might have had a positive impact on performance (e.g. because students have more time to examine it). This suggests that “cheat sheets” may be more effective to address knowledge gaps if more time is provided for the students to familiarize themselves with it before taking the test.

Regarding external validity, it is worth noting that all the observations in this analysis correspond to students from disadvantaged backgrounds who believed both that they may not be able to obtain admission in a prestigious undergraduate program in Chile, and that they were nonetheless talented enough to prevail among their peers and obtain admission through an special access program. This means that apart from maybe being more talented, these students may also be more motivated, confident, or risk-averse than their peers. Therefore, the impact of using “cheat sheets” for the general student population may differ from the one observed in this study.

Also, although as noted there were many observable differences among candidates (which were large enough to allow for the detection of some significant effects) the students in this study were relatively similar to each other (e.g. there were no students from elite private schools). This may also pose a threat to external validity, as the impact of “cheat sheets” may be larger when including students with really good secondary education in the analysis. Or, conversely, those students may benefit even more from having a knowledge summary, thus reducing the differential impact with respect to students from disadvantaged backgrounds.

Moreover, the students who took the mathematical ability test were not aware that “cheat sheets” would be provided. It is conceivable to think that if they had known about this fact, they may have prepared for the exam in a different manner. This may also affect the external validity of the results presented in this paper.

Finally, note also that the distribution of the number of correct answers seems to be skewed to the left and/or truncated on the right. This might point towards the format of the mathematical ability test custom-designed for this study to be too easy, either because the number of questions was too low, and/or because the time allowance was too long.

7. Conclusion

This paper presents a diagnostics experiment, intended to better understand the role played by admissions tests in the access to higher education. In particular, I custom-designed a multiple-choice mathematical ability test, intended to measure an individual's ability while minimizing the reliance on previously acquired specific knowledge. Moreover, I also put together a two page knowledge summary, or "cheat sheet", which outlined all the concepts which I considered necessary to successfully complete the test, without providing explicit answers to exam questions. This mathematical ability test was subsequently used to screen candidates applying for admission into one of the leading Chilean universities via a special access program. It was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into treatment and control groups. All students took the first part of the test without any support materials, but students in the treatment group had access to a "cheat sheet" before the second part of the exam, while students in the control group did not have access to a "cheat sheet" until before its third part. This staged randomization design allowed to estimate the impact of the "cheat sheet" on student test performance, by looking at the differences in the number of questions answered correctly across the three parts of the test between students in the control and treatment groups.

This paper only finds a significant difference in the number of questions answered correctly between students in the treatment and control group in Part II of the test. Since this is precisely the part in which candidates in the control group did not yet have access to the "cheat sheet" (as opposed to students in the treatment group), this suggests that *ceteris paribus* having access to a knowledge summaries results in improved academic performance. Also, this paper also finds a significant difference in the improvement (i.e. additional number of questions answered correctly) from Part I to Part II and from part II to Part III between students in the treatment and control groups. In particular, students in the treatment group perform significantly better in Part II than in Part I, compared to students in the control group (who did not have access to a "cheat sheet" during the second part of the test). Analogously, students in the control group perform significantly better in Part III than in Part II (i.e. after receiving a knowledge summary before the third part of the exam). This again suggests that having access to a knowledge summaries improves student performance on the test. Moreover, it seems that students who attended a secondary school with a higher average score in the government-administered standardized evaluation test (SIMCE) tend to answer more questions correctly, corroboration the stylized fact of positive correlation between secondary school quality and admission test performance.

While all the above makes sense, and corroborates the fact that as expected students perform better in a test if they have access to a "cheat sheet", it is not a particularly interesting set of results. However, most importantly this paper also finds significant evidence that "cheat sheets" are significantly more beneficial for those students who were more likely to have had a secondary education of lower quality. In particular, students who attended a secondary school with a lower average score in the government-administered standardized evaluation test (SIMCE) tend to experience a significantly greater differential improvement in the number of questions answered correctly when using a "cheat sheet". Or in other words, there is evidence of a significant negative effect of secondary school government-administered standardized evaluation (SIMCE) on the differential improvement in test performance after students have access to a "cheat sheet". This is observable both in the significantly greater differential improvement from Part I to Part II for students in the treatment group (i.e. after they received the "cheat sheet" at the end of the first part), and in the significantly greater differential improvement from Part II to Part III for students in the control group (i.e. after they received the "cheat sheet" at the end of the second part). Also, no differential impact is observed for the comparisons of Part III vs. Part I, consistent with the fact that all candidates completed both Part I and Part III in the same conditions (no differential impact should be expected in this case, unless having access to the "cheat sheet" for a longer amount of time does matter).

Moreover, although the results are less robust than those presented above, this paper also finds some evidence of a positive differential impact of having access to a "cheat sheet" on candidates enrolled in the PENTA UC program for talented secondary school students. Since students enrolled in the PENTA UC program come from disadvantaged backgrounds, and were already screened during their secondary education and identified as possessing "exceptional ability", this suggests that *ceteris paribus* the use of "cheat sheets" may be particularly beneficial for talented students. Also, there is some evidence that while students from public schools or the lower quintiles of the income distribution may benefit from "cheat sheets", they may need more time to do so than the amount provided between the parts of the exam in this experiment (e.g. because they may need more time to analyze and comprehend it).

Finally, a simulation exercise is performed for illustration purposes. It consists of an analysis of which candidates would benefit from (or would be worse off with) the use of cheat sheets, as measured by whether they advanced to or were relegated from the group of top 20 candidates (which is the number of vacancies available each year for admission via the special access program featured in this study). This is performed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. The results of this exercise are not robust at the candidate level, since given the reduced number of questions in each part of the test, and the left-skewed distribution of the number of correctly answered questions, there are many ties which are broken randomly. However, they provide an insight of how the introduction of "cheat sheet" may have affected the selection process, if the mathematical ability test was the only criterion used to determine admission. In particular, according to the results of this simulation exercise the use of "cheat sheets" would mainly affect students close to the cut-off, but there are also cases of very large changes in ranking from Part I to Part III of the test.

All the above has important implications for educational policies in Chile and elsewhere, suggesting that a transition to ability-focused admission tests would facilitate the access to higher education for talented students from disadvantaged backgrounds. In the long term this would likely entail a redesign of current admission tests, but interim remedies such as knowledge summaries or "open book" exams may help to alleviate access to higher education problems in the short and medium term. Also, it is worth noting that this measures would be a complement, but not a substitute to deeper educational reform. In particular, it seems that the first best solution would still involve to improve the quality of secondary education for all, in order to avoid the current formative shortcomings suffered by students from disadvantaged socioeconomic backgrounds.

TABLE I

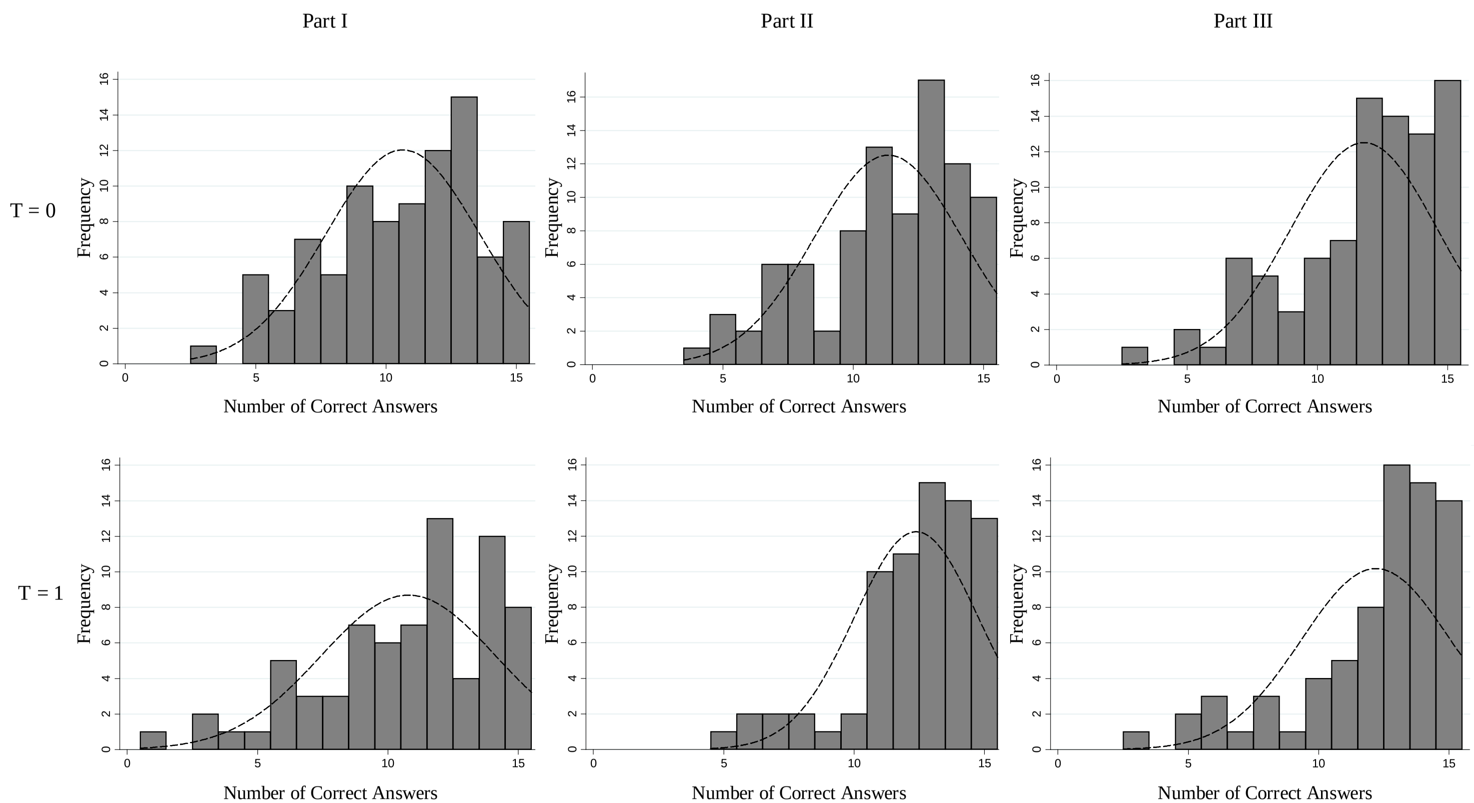
BALANCE ACROSS CONTROL AND TREATMENT GROUPS

	Control (Cheat Sheet in Part III)	Treatment (Cheat Sheet in Part II)	p-value
Secondary School Standardized Math Test Score (SIMCE)	290.52	290.00	0.95
	(5.58)	(4.96)	
Region (1 = Santiago Metropolitan Region)	0.17	0.16	0.94
	(0.04)	(0.04)	
Secondary School Type (1 = Public)	0.36	0.28	0.27
	(0.05)	(0.05)	
PENTA UC Program Fellow (1 = Yes)	0.04	0.07	0.52
	(0.02)	(0.03)	
Income Distribution Quintile (1 = I)	0.24	0.18	0.35
	(0.05)	(0.05)	
Income Distribution Quintile (1 = II)	0.26	0.33	0.35
	(0.05)	(0.06)	
Income Distribution Quintile (1 = III)	0.33	0.27	0.45
	(0.05)	(0.05)	
Gender (1 = Male)	0.42	0.47	0.53
	(0.05)	(0.06)	
Observations	89	73	

NOTES. Candidates seeking to enter the undergraduate degree via the special admission program for students from disadvantaged socioeconomic backgrounds took a multiple-choice mathematical test, which was custom-designed to try to measure the individual's ability while minimizing the reliance on previously acquired knowledge. The objective was to try to identify talented individuals who may have had a secondary education of poor quality, but who would otherwise be able to successfully complete the undergraduate degree. The mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. However, this staged randomization design allows to analyze the impact of the cheat sheet on the students' performance on the test. The above table provides an overview of the balance between control and treatment groups after the stratified random assignment. Each cell presents the mean of the balance variable (row) in group (column), and standard errors are reported between parentheses. Balance variables are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission) , (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). Reported p-values are for joint orthogonality test across control and treatment groups each of the corresponding balance variables.

FIGURE II

FREQUENCY HISTOGRAM OF NUMBER OF CORRECT ANSWERS IN EACH OF THREE PARTS OF MATHEMATICAL ABILITY TEST BY TREATMENT AND CONTROL GROUP



NOTES. The graphics above are frequency histograms for the number of correct answers in each of the three parts of the mathematical ability test (columns) by control and treatment groups (rows). As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a “cheat sheet” (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same “cheat sheet” after having completed the second part. Once they received the “cheat sheet” all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the “cheat sheet”) was considered for admission via the special access program, together with several other criteria. The vertical axes show the number of observations in each bin (i.e. the number of students who answered correctly the corresponding number of times), and the horizontal axes denote the number of correct answers in each part of the test. T = 0 denotes the control group (first row) and T = 1 denotes the treatment group. The dotted lines depict the fitted normal distributions for each subpopulation.

TABLE III

DIFFERENCES IN NUMBER OF CORRECT ANSWERS IN EACH OF THREE PARTS OF MATHEMATICAL ABILITY TEST BETWEEN TREATMENT AND CONTROL GROUPS

	Part I		Part II		Part III	
Number of Correct Answers in Each Part of the Test	(1.1)	(1.2)	(2.1)	(2.2)	(3.1)	(3.2)
Treatment (1 = Cheat Sheet in Part II)	0.164	-0.019	1.075	1.064	0.425	0.261
	(0.502)	(0.443)	(0.410)***	(0.381)***	(0.450)	(0.429)
Secondary School Standardized Math Test Score (SIMCE)		0.031		0.024		0.023
		(0.011)***		(0.008)***		(0.010)**
Region (1 = Santiago Metropolitan Region)		-0.013		-0.421		-0.022
		(0.651)		(0.579)		(0.541)
Secondary School Type (1 = Public)		-0.442		-0.408		-0.607
		(0.480)		(0.407)		(0.484)
PENTA UC Program Fellow (1 = Yes)		0.558		-0.349		-0.034
		(0.589)		(0.605)		(0.574)
Income Distribution Quintile (1 = I)		-1.361		-0.916		-1.173
		(0.720)*		(0.631)		(0.678)*
Income Distribution Quintile (1 = II)		-0.574		-0.214		-0.195
		(0.634)		(0.525)		(0.579)
Income Distribution Quintile (1 = III)		-0.257		-0.044		-0.173
		(0.499)		(0.414)		(0.483)
Gender (1 = Male)		1.753		1.281		1.380
		(0.459)***		(0.394)***		(0.444)***
Admission Year (1 = 2014)	-0.539	-0.091	-0.645	-0.210	-0.453	-0.122
	(0.500)	(0.427)	(0.411)	(0.361)	(0.445)	(0.414)
Constant Term	10.986	1.817	11.750	4.323	12.077	5.104
	(0.433)***	(3.324)	(0.370)***	(2.605)*	(0.390)***	(2.996)*
R^2	0.01	0.35	0.05	0.34	0.01	0.26
Observations	162	152	162	152	162	152

* p<0.1; ** p<0.05; *** p<0.01

NOTES. This table analyzes the differences in the number of correct answers in each of the three parts of the mathematical ability test between the randomly assigned treatment and control groups. As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. The dependent variable in all regressions (columns) is the number of correct answers in each corresponding part of the test, and independent variables are listed on the left (rows). Apart from the treatment indicator (first row), several additional controls are included in the extended specifications (1.2, 2.2 and 3.2) for robustness purposes. These are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

TABLE IV

DIFFERENCES IN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST BETWEEN TREATMENT AND CONTROL GROUPS

	Part II - Part I			Part III - Part II			Part III - Part I		
Improvement (Additional Correct Answers)	(1.0)	(1.1)	(1.2)	(2.0)	(2.1)	(2.2)	(3.0)	(3.1)	(3.2)
Treatment (1 = Cheat Sheet in Part II)	0.911	1.083	10.834	-0.650	-0.804	-11.782	0.261	0.280	-0.948
	(0.274)***	(0.294)***	(3.300)***	(0.273)**	(0.309)**	(3.331)***	(0.276)	(0.281)	(2.330)
Secondary School Standardized Math Score		-0.006	0.002		-0.001	-0.008		-0.007	-0.005
		(0.004)	(0.003)		(0.004)	(0.003)**		(0.003)**	(0.003)*
Region (1 = Santiago Metropolitan Region)		-0.408	0.007		0.398	0.441		-0.009	0.448
		(0.378)	(0.455)		(0.422)	(0.467)		(0.428)	(0.512)
Secondary School Type (1 = Public)		0.034	0.323		-0.198	0.270		-0.165	0.593
		(0.333)	(0.320)		(0.368)	(0.396)		(0.314)	(0.390)
PENTA UC Program Fellow (1 = Yes)		-0.907	-1.446		0.315	0.319		-0.592	-1.126
		(0.424)**	(0.348)***		(0.360)	(0.464)		(0.517)	(0.501)**
Income Distribution Quintile (1 = I)		0.446	0.422		-0.257	-0.999		0.188	-0.577
		(0.391)	(0.423)		(0.461)	(0.566)*		(0.461)	(0.583)
Income Distribution Quintile (1 = II)		0.360	0.575		0.019	-0.712		0.379	-0.137
		(0.376)	(0.464)		(0.364)	(0.523)		(0.401)	(0.545)
Income Distribution Quintile (1 = III)		0.213	0.310		-0.129	-0.273		0.084	0.037
		(0.352)	(0.412)		(0.350)	(0.489)		(0.404)	(0.537)
Gender (1 = Male)		-0.472	-0.353		0.100	0.183		-0.373	-0.170
		(0.260)*	(0.305)		(0.281)	(0.340)		(0.272)	(0.316)
Admission Year (1 = 2014)	-0.106	-0.119	-0.093	0.192	0.088	0.420	0.086	-0.031	0.328
	(0.275)	(0.282)	(0.317)	(0.282)	(0.312)	(0.369)	(0.279)	(0.307)	(0.425)
Secondary School Standardized Math Score			-0.032			0.027			-0.005
* Treatment			(0.007)***			(0.008)***			(0.006)
Region (1 = Santiago Metropolitan Region)			-0.843			-0.302			-1.145
* Treatment			(0.728)			(0.789)			(0.821)
Secondary School Type (1 = Public)			0.222			1.547			1.769
* Treatment			(0.698)			(0.681)**			(0.549)***
PENTA UC Program Fellow (1 = Yes)			1.488			0.155			1.643
* Treatment			(0.667)**			(0.989)			(0.807)**
Income Distribution Quintile (1 = I)			-0.857			2.017			1.160
* Treatment			(0.822)			(0.953)**			(0.930)
Income Distribution Quintile (1 = II)			-0.974			1.730			0.756
* Treatment			(0.793)			(0.717)**			(0.829)
Income Distribution Quintile (1 = II)			-1.007			0.722			-0.285
* Treatment			(0.693)			(0.705)			(0.824)
Gender (1 = Male)			-0.407			-0.165			-0.572
* Treatment			(0.532)			(0.580)			(0.570)
Admission Year (1 = 2014)			0.080			-0.717			-0.637
* Treatment			(0.544)			(0.592)			(0.592)
Constant Term	0.765	2.506	-0.290	0.326	0.781	2.745	1.091	3.287	2.455
	(0.209)***	(1.270)*	(0.836)	(0.228)	(1.166)	(1.136)**	(0.247)***	(0.908)***	(0.995)**
R^2	0.07	0.16	0.33	0.04	0.06	0.18	0.01	0.09	0.20
Observations	162	152	152	162	152	152	162	152	152

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. See next page.

TABLE IV

DIFFERENCES IN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST BETWEEN TREATMENT AND CONTROL GROUPS

NOTES. This table analyzes the differences in the improvement (additional correct answers) across each of the parts of the mathematical ability test between the randomly assigned treatment and control groups. As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a "cheat sheet" (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same "cheat sheet" after having completed the second part. Once they received the "cheat sheet" all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the "cheat sheet") was considered for admission via the special access program, together with several other criteria. The dependent variable in all regressions (columns) is the number of additional correct answers across corresponding parts of the test, and independent variables are listed on the left (rows). For example, in columns (1.0, 1.1 and 1.2 the dependent variable is the number of additional correct answers for each students in Part II of the mathematical ability test, compared to Part I. Apart from the treatment indicator (x.0), several additional controls are included in the (x.1) specifications for robustness purposes. The (x.3) specifications further include the interaction terms between the treatment indicator and the additional controls. The latter are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

TABLE V

RELATIONSHIP BETWEEN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST AND STUDENT CHARACTERISTICS

Part I – Part II (Treatment = 1, i.e. Cheat Sheet from Part II)	(0.1)	(1.1)	(2.1)	(3.1)	(4.1)	(5.1)	(6.1)
Secondary School Standardized Math Test Score (SIMCE)	-0.029	-0.027					
	(0.007)***	(0.004)***					
Region (1 = Santiago Metropolitan Region)	-0.836		-0.472				
	(0.573)		(0.595)				
Secondary School Type (1 = Public)	0.101			-0.870			
	(0.626)			(0.548)			
PENTA UC Program Fellow (1 = Yes)	0.042				-0.617		
	(0.574)				(0.598)		
Income Distribution Quintile (1 = I)	-0.435					1.118	
	(0.712)					(0.653)*	
Income Distribution Quintile (1 = II)	-0.398					0.667	
	(0.649)					(0.535)	
Income Distribution Quintile (1 = III)	-0.696					0.442	
	(0.563)					(0.598)	
Gender (1 = Male)	-0.760						-0.670
	(0.440)*						(0.427)
Admission Year (1 = 2014)	-0.013	-0.208	-0.179	-0.212	-0.240	-0.331	-0.190
	(0.446)	(0.452)	(0.514)	(0.536)	(0.517)	(0.467)	(0.506)
Constant Term	10.988	9.685	1.803	2.004	1.809	1.290	2.045
	(2.175)***	(1.530)***	(0.442)***	(0.469)***	(0.450)***	(0.440)***	(0.521)***
R^2	0.39	0.33	0.01	0.04	0.01	0.04	0.04
Observations	68	68	73	68	73	73	73
Part III – Part II (Treatment = 0, i.e. Cheat Sheet from Part III)	**(0.2)**	**(1.2)**	**(2.2)**	**(3.2)**	**(4.2)**	**(5.2)**	**(6.2)**
Secondary School Standardized Math Test Score (SIMCE)	-0.008	-0.006					
	(0.003)**	(0.003)**					
Region (1 = Santiago Metropolitan Region)	0.441		0.351				
	(0.464)		(0.474)				
Secondary School Type (1 = Public)	0.270			0.012			
	(0.394)			(0.366)			
PENTA UC Program Fellow (1 = Yes)	0.319				0.071		
	(0.461)				(0.499)		
Income Distribution Quintile (1 = I-III)	-0.999					-0.551	
	(0.562)*					(0.537)	
Income Distribution Quintile (1 = V)	-0.712					-0.435	
	(0.519)					(0.506)	
Income Distribution Quintile (1 = III)	-0.273					-0.224	
	(0.486)					(0.452)	
Gender (1 = Male)	0.183						-0.016
	(0.338)						(0.338)
Admission Year (1 = 2014)	0.420	0.356	0.368	0.437	0.418	0.451	0.408
	(0.367)	(0.322)	(0.354)	(0.356)	(0.355)	(0.347)	(0.336)
Constant Term	2.745	1.965	0.155	0.182	0.179	0.493	0.194
	(1.128)**	(0.898)**	(0.242)	(0.322)	(0.267)	(0.346)	(0.307)
R^2	0.10	0.05	0.02	0.02	0.01	0.03	0.01
Observations	84	86	89	85	89	88	89

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

NOTES. See next page.

TABLE V

RELATIONSHIP BETWEEN IMPROVEMENT (ADDITIONAL CORRECT ANSWERS) ACROSS PARTS OF MATHEMATICAL ABILITY TEST AND STUDENT CHARACTERISTICS

NOTES. This table analyzes the relationship between improvement (additional correct answers) across each of the parts of the mathematical ability test and the student characteristics. Each column corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other. In the first set of regressions (x.1) the dependent variable is the improvement between Part I and Part II of the test for students in the treatment group, who received the cheat sheet before taking the second part of the exam. In the second set of regressions (x.2) the dependent variable is the improvement between Part II and Part III of the test for students in the control group, who received the cheat sheet before taking the third part of the exam. All six independent variables are first considered jointly (0.x) and then separately (1.x-6.x). These are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, , (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

TABLE VI

ROSTER OF STUDENTS WHO BENEFIT FROM OR ARE WORSE OFF WITH THE USE OF CHEAT SHEETS

	Part I		Part II		Part III		
	Rank	Correct Answers	Rank	Correct Answers	Rank	Correct Answers	Treatment
Students Who Are Better Off With Cheat Sheet	22	14	28	14	8	15	1
(i.e. in Top 20 on Part III but not on Part I)	25	14	17	15	10	15	0
	31	14	7	15	2	15	1
	40	13	52	13	5	15	0
	42	13	74	13	3	15	0
	44	13	14	15	6	15	1
	49	13	78	13	9	15	0
	65	12	118	11	1	15	1
	68	12	61	13	18	15	1
	69	12	38	14	20	15	0
	72	12	93	12	12	15	0
	88	11	71	13	19	15	1
Total: 13	103	10	121	11	4	15	1
Students Who Are Worse Off With Cheat Sheet	1	15	43	14	26	15	0
(i.e. in Top 20 on Part I but not on Part III)	3	15	20	15	25	15	0
	4	15	41	14	57	14	1
	7	15	26	14	79	13	1
	8	15	15	15	78	13	0
	10	15	24	14	53	14	1
	11	15	21	15	24	15	0
	12	15	9	15	33	14	0
	13	15	5	15	32	14	1
	16	15	32	14	36	14	0
	18	14	62	13	85	13	1
	19	14	16	15	49	14	0
Total: 13	20	14	35	14	40	14	1

NOTES. As already mentioned, the mathematical test was divided in three parts, which featured 15 analogous questions each (i.e. the first questions of each part were different but analogous), and candidates were randomly divided into stratified treatment and control groups. All students took the first part of the test without any support materials, but then a “cheat sheet” (i.e. knowledge summaries outlining the basic concepts needed to successfully answer the test questions) was distributed to each of the candidates in the treatment group, who then had about ten minutes to examine it before the second part started. Students in the control group simply had a ten minute break after completing the first part of the test, but received the same “cheat sheet” after having completed the second part. Once they received the “cheat sheet” all students could keep it with them until the end of the test, and for fairness purposes only the number of correct answers from the third part (which all students took with the aid of the “cheat sheet”) was considered for admission via the special access program, together with several other criteria. This table presents a roster of all the students who benefit from or are worse off with the use of cheat sheets, as measured by whether they advanced to or were relegated from the group of top 20 candidates who would be admitted via the special access program, respectively. This is observed by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct students are resolved randomly. Each row corresponds to one student, for which the rank and number of correct answers in each of the three parts of the mathematical ability test are listed. The last column indicates whether the student was in the treatment or control group.

TABLE VII

RELATIONSHIP BETWEEN STUDENT CHARACTERISTICS AND THE LIKELIHOOD OF BENEFITING FROM AND BEING WORSE OFF WITH THE USE OF CHEAT SHEETS

1 = Student Better Off With Cheat Sheet	(0.1)	(1.1)	(2.1)	(3.1)	(4.1)	(5.1)	(6.1)
Secondary School Standardized Math Test Score (SIMCE)	0.001	0.001					
	(0.000)*	(0.000)					
Region (1 = Santiago Metropolitan Region)	-0.062		-0.050				
	(0.054)		(0.044)				
Secondary School Type (1 = Public)	-0.048			-0.039			
	(0.045)			(0.044)			
PENTA UC Program Fellow (1 = Yes)	-0.067				-0.090		
	(0.036)*				(0.026)***		
Income Distribution Quintile (1 = I)	-0.008					-0.035	
	(0.058)					(0.058)	
Income Distribution Quintile (1 = II)	0.023					-0.000	
	(0.064)					(0.059)	
Income Distribution Quintile (1 = III)	0.085					0.078	
	(0.072)					(0.067)	
Gender (1 = Male)	0.035						0.033
	(0.053)						(0.044)
Admission Year (1 = 2014)	0.005	-0.007	-0.009	-0.017	-0.021	-0.002	-0.017
	(0.051)	(0.049)	(0.047)	(0.048)	(0.047)	(0.047)	(0.047)
Constant	-0.112	-0.073	0.095	0.109	0.099	0.066	0.077
	(0.117)	(0.116)	(0.040)**	(0.044)**	(0.041)**	(0.045)	(0.044)*
R^2	0.05	0.01	0.01	0.00	0.01	0.03	0.00
N	152	154	162	153	162	161	162
1 = Student Worse Off With Cheat Sheet)	(0.2)	(1.2)	(2.2)	(3.2)	(4.2)	(5.2)	(6.2)
Secondary School Standardized Math Test Score (SIMCE)	0.002	0.002					
	(0.001)**	(0.001)***					
Region (1 = Santiago Metropolitan Region)	-0.030		-0.050				
	(0.047)		(0.050)				
Secondary School Type (1 = Public)	0.106			0.172			
	(0.052)**			(0.063)***			
PENTA UC Program Fellow (1 = Yes)	0.083				0.148		
	(0.124)				(0.146)		
Income Distribution Quintile (1 = I)	-0.094					-0.164	
	(0.086)					(0.086)*	
Income Distribution Quintile (1 = II)	-0.089					-0.160	
	(0.085)					(0.085)*	
Income Distribution Quintile (1 = III)	-0.167					-0.206	
	(0.076)**					(0.079)**	
Gender (1 = Male)	0.000						0.033
	(0.043)						(0.044)
Admission Year (1 = 2014)	0.020	0.011	-0.009	0.010	-0.008	-0.018	-0.017
	(0.054)	(0.047)	(0.051)	(0.052)	(0.050)	(0.048)	(0.047)
Constant	-0.381	-0.550	0.095	0.022	0.077	0.237	0.077
	(0.218)*	(0.205)***	(0.039)**	(0.049)	(0.043)*	(0.083)***	(0.040)*
R^2	0.23	0.13	0.01	0.08	0.02	0.07	0.00
N	152	154	162	153	162	161	162

* p<0.1; ** p<0.05; *** p<0.01

NOTES. See next page.

TABLE VII

RELATIONSHIP BETWEEN STUDENT CHARACTERISTICS AND THE LIKELIHOOD OF BENEFITING FROM AND BEING WORSE OFF WITH THE USE OF CHEAT SHEETS

NOTES. This table analyzes the relationship between student characteristics and the likelihood of benefitting from or being worse off with the use of cheat sheets, as measured by the likelihood of advancing to or being relegated from the group of top 20 candidates who would be admitted via the special access program, respectively. This is obtained by comparing the rank of each candidate in Part I (which all students completed without a cheat sheet) and Part III (which all students completed with a cheat sheet), as defined by the number of correct answers relative to the other students who took the exam. Ties among students with the same number of correct students are resolved randomly. Each column corresponds to one regression specification, and independent variables are listed on the left (rows). Two sets of specifications are presented stacked over each other. In the first set of regressions (x.1) the dependent variable is the binomial indicator of whether the student benefited from the use of a cheat sheet, i.e. whether s/he made it to the top 20 in Part III but not Part I. In the second set of regressions (x.2) the dependent variable is the binomial indicator of whether the student was worse off with the use of a cheat sheet, i.e. whether s/he made it to the top 20 in Part I but not Part III. All six independent variables are first considered jointly (0.x) and then separately (1.x-6x). These are: (i) the math score obtained in the standardized test administered to secondary school students (SIMCE) (ii) whether the student attended a secondary school in the Santiago Metropolitan Region, (iii) whether the student attended a public school, as opposed to a subsidized one (private school students were not eligible to apply for special admission), (iv) whether the student attended the PENTA UC program for talented secondary school students, (v) whether the student belongs to the lower three quintiles of the income distribution, as opposed to the fourth quintile (fifth quintile students were not eligible to apply for special admission), and (vi) the student's gender (1 = male). A 2014 admission year fixed effect is included (base category is admission year 2013). Huber-White heteroskedasticity-consistent standard errors are reported between parentheses.

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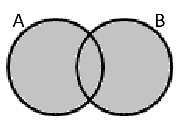
Appendix A: Basic Math Concepts "Cheat Sheet" (Spanish Original)

CONSEJOS GENERALES

- Lee cuidadosamente el enunciado de cada pregunta, prestando especial atención a los paréntesis y operadores matemáticos. ¡Es muy importante no malinterpretar el enunciado de la pregunta o las posibles respuestas! Siempre resuelve la operación dentro de los paréntesis primero.
- Por simplicidad en esta prueba la división se representa mediante el símbolo "/", mientras que el operador multiplicativo se omite y se usan paréntesis para separar los múltiplos. Es decir, 3 / 3 =1, y (3)(3) = 9.

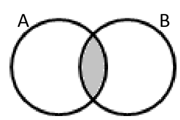
CONJUNTOS

Unión de Conjuntos



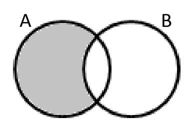
A ∪ B

Intersección de Conjuntos



A ∩ B

Diferencia de Conjuntos



A - B

PORCENTAJES

X% = X/100	→ *Por ejemplo, 20% = 20 / 100 = 0,2*
"X% de Y" = (X/100)(Y)	→ *Por ejemplo, "20% de 50" = (20 / 100) (50) = 10*
"sube un X%" significa (100 + X)%	→ *Por ejemplo, si 50 aumenta un 20%, tenemos (100 + 20)% de 50 = 60*
"baja un X%" significa (100 - X)%	→ *Por ejemplo, si 50 baja un 20%, tenemos (100 - 20)% de 50 = 40*
"A es X% más grande que B" significa que [(A-B) / B] (100) = X%	→ *Por ejemplo, "375 es un 25% más grande que 300", ya que [(375-300) / 300] (100) = 0.25 = 25%, o lo que es lo mismo, 375 = (1,25)(300) = (1 + 0,25) (300), es decir, 375 es un 125% de 300*
"B es X% más pequeño que A" significa que [(A-B) / A] (100) = X%	→ *Por ejemplo, "150 es un 25% más pequeño que 200", ya que [(200-150) /200] (100) = 0.25 = 25%, o lo que es lo mismo, 150 = (0,75) (200) = (1 – 0,25)(200), es decir, 150 es un 75% de 200*

RAZONES

"razón de X a Y" es X:Y=X/Y	→ *Por ejemplo, razón de 8 a 4 es 8:4=8/4=2/1=2:1*
[(X)(Y)]/[(X)(Z)]=Y/Z	→ *Por ejemplo, 8/6=[(2)(4)] /[(2)(3)]=4/3*
[X/Y]/[Z/W]= [(X)(W)]/[(Y)(Z)]	→ *Por ejemplo, [10/5]/[6/3]= [(10)(3)]/[(5)(6)]=30/30=1*
"X/Y = Z/W" implica que X=(Z)(Y) /W	→ *Por ejemplo, si X/2=4/6, esto implica que X=(4)(2) /6=8/6=4/3*
"X/Y = Z/W" puede ser leído como "X es a Y como Z es a W"	→ *Por ejemplo, X/2=4/6 puede ser leído como "X es a 2 como 4 es a 6"*
"X en Y horas" implica "(1/Y)X por hora", o "[(1/Y)X] / hora"	→ *Por ejemplo, "10 en 5 horas" implica "2 por hora", o "2/hora"*

EXPONENTES

$X^{(-a)} = 1/X^a$ $\quad$ $(X^a)(X^b) = X^{(a+b)}$ $\quad$ $(X^a)^b = X^{(a)(b)}$

$X^a/X^b = (X^a)(X^{(-b)}) = X^{(a-b)}$ $\quad$ $(X^a)(Y^a) = [(X)(Y)]^a$ $\quad$ $X^a/Y^a = (X^a)(Y^{(-a)}) = [X/Y]^a$

ÁLGEBRA

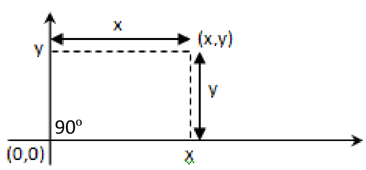
$A=a \rightarrow X^A = X^a$ $\quad$ $aX + b = cX + d \leftrightarrow aX - cX = (a-c)X = d - b$ $\quad$ $aX = b \leftrightarrow X = b/a$

$aX + b > cX + d \leftrightarrow aX - cX = (a-c)X > d - b$ $\quad$ → *Por ejemplo,* $2X + 1 > X + 2 \leftrightarrow 2X - X = (2-1)X = X > 2 - 1 = 1$

Si $a > 0$, entonces $aX > b \leftrightarrow X > b/a$, $\quad$ → *Por ejemplo,* $2X > 4 \leftrightarrow X > 4/2=2$, *pero* $-2X > 4 \leftrightarrow X < 4/(-2)=(-2)$

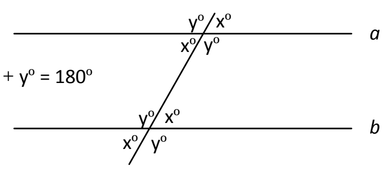
GEOMETRÍA

Eje de Coordenadas (x,y)

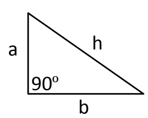


Ángulos

NOTA: Las líneas a y b son paralelas

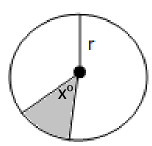


Teorema de Pitágoras



$h^2 = a^2 + b^2$

Área de un círculo y volumen de un cilindro



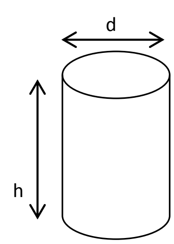
r = radio

d = diámetro

h = altura

Área de una sección de un círculo (sombreada)

área sección determinada por el ángulo xº = $(x/360)(\pi r^2)$



$d = 2r$

área círculo = πr^2

volumen cilindro = $h\,\pi r^2$

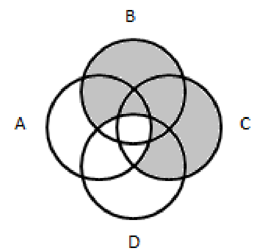
Medida de ángulos interiores de un polígono

La suma de los ángulos interiores de un polígono de n lados es (n-2)(180º)

→ *Por ejemplo, los ángulos interiores de un triángulo suman 180º, los de un cuadrado suman 360º, etc.*

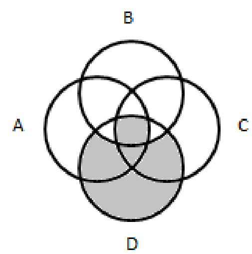
Appendix B: Mathematical Ability Test Part I (Spanish Original)

1. En la figura de la derecha A, B, C y D son círculos de igual tamaño.
El área sombreada representa:



A. (A ∪ D) – (B ∩ C)
B. (A ∪ B) – (C ∩ D)
C. (A ∩ B) – (C ∪ D)
D. (B ∪ C) – (A ∩ D)
E. (A ∩ B) – (C ∩ D)

2. En la figura de la derecha A, B, C y D son círculos de igual tamaño.
El área sombreada representa:



A. (B – D) U [(A ∩ C) ∩ (B ∪ D)]
B. (D – B) U [(A ∩ B) ∩ (C ∩ D)]
C. (C – D) U [(A ∩ B) ∪ (C ∩ D)]
D. (C – B) U [(A ∩ B) ∪ (C ∩ D)]
E. (A – D) U [(A ∩ B) ∩ (C ∩ D)]

3. El precio inicial de un auto era de seis millones de pesos. El precio del auto subió un 20% con respecto a su precio inicial, pero después bajó un 20% con respecto a su precio máximo. ¿Cuál es la diferencia entre el precio inicial y el precio actual del auto?

A. $ 120.000
B. $ 150.000
C. $ 0
D. $ 300.000
E. $ 240.000

4. Se considera que el precio de una mercancía es "estable" si la diferencia entre su precio mínimo y su precio máximo no es mayor que un 10% de su precio medio. Según la información de la tabla, ¿qué mercancías tienen precios "estables"?

A. B y C
B. B y D
C. A y B
D. A y C
E. Ninguna

Mercancía	Pr. Mínimo	Pr. Medio	Pr. Máximo
A	$ 114	$ 120	$ 125
B	$ 47	$ 50	$ 51
C	$ 9	$ 10	$ 11
D	$ 77	$ 70	$ 85

5. Si la razón de mujeres a hombres en un comité de 30 miembros es de 3:2, y el 50% por ciento de las mujeres son chilenas y el 25% de los hombres son extranjeros, ¿cuántos miembros del comité son chilenos?

A. 16
B. 22
C. 24
D. 18
E. 20

6. Diez obreros realizan una obra en siete días. ¿En cuántos días se hubiese realizado una obra un 30% más grande si se hubiesen ocupado cinco obreros?

   A. 12,6 días
   B. 14,8 días
   C. 20,6 días
   D. 16,4 días
   E. 18,2 días

7. Una llave de agua llena la piscina A en seis horas, y otra llave de agua llena la piscina B, que es un 50% más grande que la piscina A, en la mitad de tiempo. ¿Cuánto tardarían en llenar la piscina A las dos llaves de agua al mismo tiempo?

   A. 1,5 horas
   B. 3 horas
   C. 2 horas
   D. 1 hora
   E. 2,5 horas

8. ¿Cuál es el valor de $[(X^{A})(X^{(-B)})]^{B}$ cuando X=4, A=3, B=2?

   A. 9
   B. 16
   C. 36
   D. 25
   E. 4

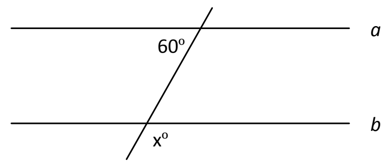
9. $[(X^{10})\ (Y^{(-1)})]\ /\ [(Y^{5})(X^{5})]$ es igual a:

   A. X^{15} / Y^{4}
   B. X^{5} / Y^{4}
   C. X^{5} / Y^{6}
   D. X^{15} / Y^{6}
   E. X^{10} / Y^{4}

10. Si 4X-5X + 8 > 3X + 20, entonces:

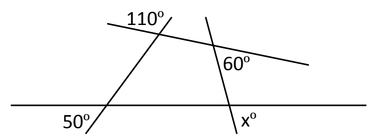
   A. X < 5
   B. X < -1
   C. X < 2
   D. X < 1
   E. X < -3

11. En la figura de la derecha las líneas *a* y *b* son paralelas.
 ¿Cuántos grados mide el ángulo x^{o} ?



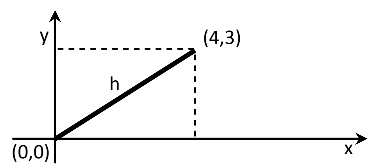
   A. $x^{o} = 130^{o}$
   B. $x^{o} = 120^{o}$
   C. $x^{o} = 140^{o}$
   D. $x^{o} = 135^{o}$
   E. $x^{o} = 125^{o}$

12. ¿En la figura de la derecha, cuántos grados mide el ángulo x^{o} ?



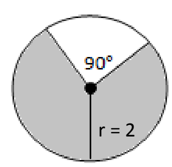
   A. $x^{o} = 85^{o}$
   B. $x^{o} = 70^{o}$
   C. $x^{o} = 80^{o}$
   D. $x^{o} = 75^{o}$
   E. $x^{o} = 65^{o}$

13. En el eje de coordenadas (x,y) a la derecha,
 ¿cuál es la longitud de la línea h entre los puntos (0,0) y (4,3)?



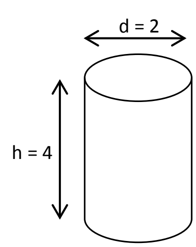
   A. h=5
   B. h=6
   C. h=4
   D. h=3
   E. h=7

14. El círculo de la derecha tiene un radio r = 2.
 ¿Cuál es el área de la zona sombreada?



   A. 4π
   B. 16π
   C. 9π
   D. 3π
   E. 2π

15. El cilindro de la derecha tiene una base circular de diámetro d = 2,
 y una altura h = 4. ¿Cuál es su volumen?

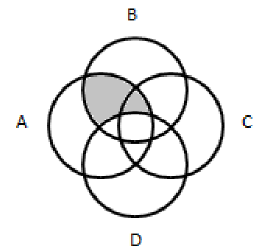


   A. 4π
   B. 16π
   C. 9π
   D. 3π
   E. 2π

Appendix C: Mathematical Ability Test Part II (Spanish Original)

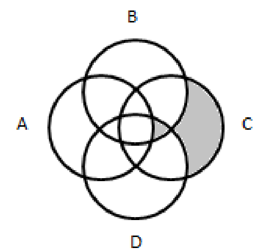
16. En la figura de la derecha A, B, C y D son círculos de igual tamaño.
El área sombreada representa:

A. (A ∪ C) – D
B. (B ∩ D) – A
C. (C ∪ D) – B
D. (B ∩ C) – A
E. (A ∩ B) – D



17. En la figura de la derecha A, B, C y D son círculos de igual tamaño.
El área sombreada representa:

A. [D – (B ∩ C)] ∪ [(A ∪ D) - C]
B. [B – (A ∪ C)] ∩ [(B ∪ C) - D]
C. [C – (B ∪ D)] ∪ [(B ∩ D) - A]
D. [B – (C ∩ D)] ∩ [(A ∩ B) - C]
E. [C – (A ∪ B)] ∪ [(B ∪ D) - A]



18. El precio inicial de un auto era de ocho millones de pesos. El precio del auto subió un 10% con respecto a su precio inicial, pero después bajó un 20% con respecto a su precio máximo. ¿Cuál es la diferencia entre el precio inicial y el precio actual del auto?

A. $ 720.000
B. $ 960.000
C. $ 540.000
D. $ 380.000
E. $ 800.000

19. Se considera que el precio de una mercancía es "estable" si la diferencia entre su precio mínimo y su precio máximo no es mayor que un 30% de su precio medio. Según la información de la tabla, ¿qué mercancías tienen precios "estables"?

A. A y B
B. B y C
C. A y C
D. C y D
E. Ninguna

Mercancía	Pr. Mínimo	Pr. Medio	Pr. Máximo
A	$ 69	$ 80	$ 94
B	$ 44	$ 40	$ 57
C	$ 9	$ 10	$ 11
D	$ 95	$ 110	$ 126

20. Si la razón de mujeres a hombres en un comité de 70 miembros es de 4:3, y el 20% por ciento de las mujeres son extranjeras y el 60% de los hombres son chilenos, ¿cuántos miembros del comité son extranjeros?

A. 18
B. 16
C. 14
D. 22
E. 20

21. Cinco obreros realizan una obra en diez días. ¿En cuántos días se hubiese realizado una obra un 20% más pequeña si se hubiesen ocupado veinte obreros?

    A. 2 días
    B. 8 días
    C. 5 días
    D. 6 días
    E. 4 días

22. Una llave de agua llena la piscina A en ocho horas, y otra llave de agua llena la piscina B, que es un 25% más pequeña que la piscina A, en un 50% más de tiempo. ¿Cuánto tardarían en llenar la piscina B las dos llaves de agua al mismo tiempo?

    A. 2 horas
    B. 3 horas
    C. 2,5 horas
    D. 4 horas
    E. 3,5 horas

23. ¿Cuál es el valor de $[(X^{(-A)}) / (X^{B})]^{A}$ cuando X=3, A=2, B=(-4)?

    A. 121
    B. 144
    C. 100
    D. 81
    E. 64

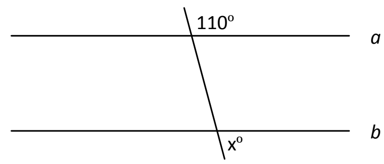
24. $[(Y^{(-6)}) / (X^{(-2)})]\ [(X^{3}) / (Y^{2})]$ es igual a:

    A. X^{5} / Y^{8}
    B. X / Y^{4}
    C. X^{5} / Y^{4}
    D. Y^{8} / X^{5}
    E. $X / Y^{(-4)}$

25. Si $6X-4X + 5 < X + 10$, entonces:

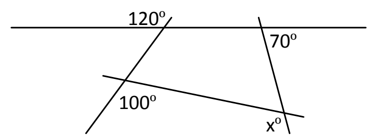
    A. $X > 4$
    B. $X < 3$
    C. $X < 4$
    D. $X > 5$
    E. $X < 5$

26. En la figura de la derecha las líneas *a* y *b* son paralelas.
¿Cuántos grados mide el ángulo xº ?



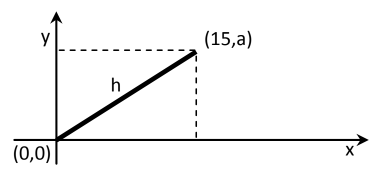
A. xº = 60 º
B. xº = 80 º
C. xº = 70 º
D. xº = 50 º
E. xº = 40 º

27. ¿En la figura de la derecha, cuántos grados mide el ángulo xº ?



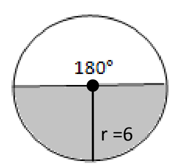
A. xº = 125 º
B. xº = 130 º
C. xº = 115 º
D. xº = 110 º
E. xº = 120 º

28. En el eje de coordenadas (x,y) a la derecha, si la línea entre los puntos (0,0) y (15,a) tiene una longitud h= 17, ¿cuál es el valor de a?



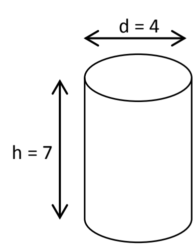
A. a=9
B. a=10
C. a=8
D. a=11
E. a=7

29. El círculo de la derecha tiene un radio r = 6.
¿Cuál es el área de la zona sombreada?



A. 18π
B. 16π
C. 20π
D. 12π
E. 14π

30. El cilindro de la derecha tiene una base circular de diámetro d = 4, y una altura h = 7. ¿Cuál es su volumen?

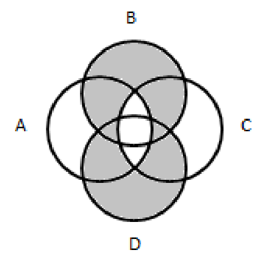


A. 24π
B. 28π
C. 32π
D. 36π
E. 20π

Appendix D: Mathematical Ability Test Part III (Spanish Original)

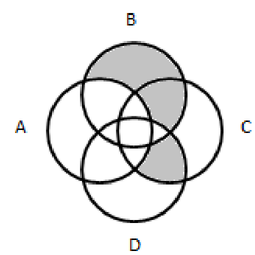
31. En la figura de la derecha A, B, C y D son círculos de igual tamaño.
    El área sombreada representa:

    A. [A ∩ C] – [D ∪ B]
    B. [B ∪ D] – [A ∩ C]
    C. [C ∪ D] – [A ∩ B]
    D. [B ∪ C] – [A ∪ D]
    E. [A ∪ B] – [C ∩ D]



32. En la figura de la derecha A, B, C y D son círculos de igual tamaño.
    El área sombreada representa:

    A. [(A ∪ C) – (B ∪ D)] ∪ [A - (B ∪ D)]
    B. [(B ∩ C) – (A ∩ D)] ∪ [C - (B ∪ C)]
    C. [(A ∪ B) – (C ∪ D)] ∪ [A - (C ∩ D)]
    D. [(C ∩ D) – (A ∪ B)] ∪ [B - (A ∪ D)]
    E. [(A ∩ D) – (C ∩ D)] ∪ [A - (C ∩ D)]



33. El precio inicial de un auto era de diez millones de pesos. El precio del auto bajó un 25% con respecto a su precio inicial, pero después subió un 35% con respecto a su precio mínimo. ¿Cuál es la diferencia entre el precio inicial y el precio actual del auto?

    A. $ 125.000
    B. $ 115.000
    C. $ 135.000
    D. $ 155.000
    E. $ 145.000

34. Se considera que el precio de una mercancía es "estable" si la diferencia entre su precio mínimo y su precio máximo no es mayor que un 25% de su precio medio. Según la información de la tabla, ¿qué mercancías tienen precios "estables"?

    A. B y C
    B. C y D
    C. A y D
    D. B y D
    E. Ninguna

Mercancía	Pr. Mínimo	Pr. Medio	Pr. Máximo
A	$ 18	$ 20	$ 22
B	$ 52	$ 60	$ 68
C	$ 61	$ 70	$ 79
D	$ 113	$ 130	$ 145

35. Si la razón de mujeres a hombres en un comité de 45 miembros es de 4:5, y el 20% por ciento de las mujeres son chilenas y el 60% de los hombres son extranjeros, ¿cuántos miembros del comité son chilenos?

    A. 12
    B. 14
    C. 10
    D. 16
    E. 18

36. Seis obreros realizan una obra en veinte días. ¿En cuántos días se hubiese realizado una obra un 40% más pequeña si se hubiesen ocupado ocho obreros?

A. 10 días
B. 8,5 días
C. 10,5 días
D. 9,5 días
E. 9 días

37. Una llave de agua llena la piscina A en 12 horas, y otra llave de agua llena la piscina B, que es un 75% más pequeña que la piscina A, en la mitad de tiempo. ¿Cuánto tardarían en llenar la piscina A las dos llaves de agua al mismo tiempo?

A. 8 horas
B. 2 horas
C. 4 horas
D. 10 horas
E. 6 horas

38. ¿Cuál es el valor de $[(X^A)(X^B)]^B$ cuando X=2, A=1, B=(-3)?

A. 16
B. 32
C. 64
D. 4
E. 2

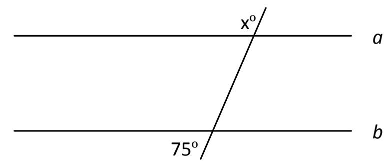
39. $[(Y^4)(X^{(-3)})] / [(Y^5) / (X^4)]$ es igual a:

A. Y^9 / X^7
B. X / Y
C. X^7 / Y^9
D. Y / X
E. X^7 / Y

40. Si $5X - 7X - 6 > 16 - 4X$, entonces:

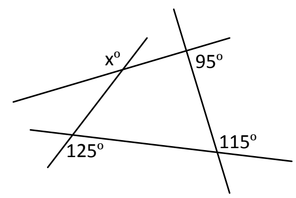
A. $X < 21$
B. $X > 7$
C. $X < 3$
D. $X > 11$
E. $X < 9$

41. En la figura de la derecha las líneas *a* y *b* son paralelas.
¿Cuántos grados mide el ángulo x^o ?



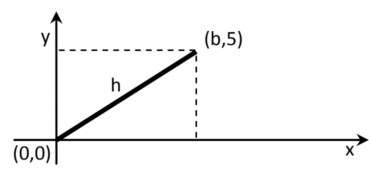
A. $x^o = 115^o$
B. $x^o = 100^o$
C. $x^o = 110^o$
D. $x^o = 120^o$
E. $x^o = 105^o$

42. ¿En la figura de la derecha, cuántos grados mide el ángulo x^o ?



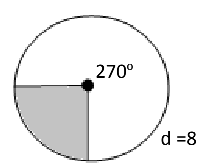
A. $x^o = 150^o$
B. $x^o = 145^o$
C. $x^o = 160^o$
D. $x^o = 140^o$
E. $x^o = 155^o$

43. En el eje de coordenadas (x,y) a la derecha, si la línea entre los puntos (0,0) y (b,5) tiene una longitud h= 13, ¿cuál es el valor de b?



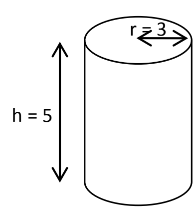
A. b=12
B. b=7
C. b=10
D. b=8
E. b=9

44. El círculo de la derecha tiene un diámetro d = 8.
¿Cuál es el área de la zona sombreada?



A. 16π
B. 8π
C. 2π
D. 4π
E. π

45. El cilindro de la derecha tiene una base circular de radio r = 3, y una altura h = 5. ¿Cuál es su volumen?



A. 30π
B. 40π
C. 45π
D. 35π
E. 50π